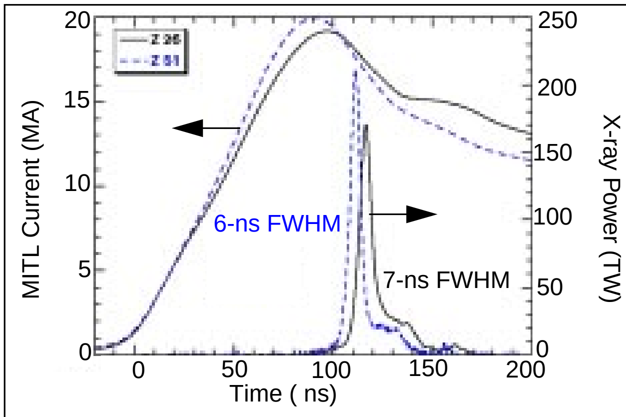
March 1997 Highlights of the Pulsed Power Inertial Confinement Fusion Program



Load current and radiated power vs time for 17th (Shot 26) and 38th (Shot 51) radiation shots. Both PBFA-Z shots used 240 7.5-µm tungsten wires in a 4-cm-diameter array.

This month we increased the peak radiated power in x rays on PBFA Z to 200 TW. We completed a study of radiated energy and power scaling for tungsten wire arrays ranging from 2 to 4 cm diameter in preparation for experiments with a wire array inside a vacuum hohlraum that begin April 1. A 3-cm array was selected for these experiments.

An external review of our pulsed power research was held on March 24 and 25. During the preliminary outbriefing, the Welch Committee praised the dramatic progress made in the past year and recommended that a significant portion of the facility time on PBFA Z for the next two to three years be devoted to weapons physics experiments and to development of new diagnostics to understand better the high energy density environment produced by imploding z pinches.

On March 26 we repeated the 4-cm-diameter array shot (Shot 26, November 21) that gave the best radiated energy and power (1.8 MJ and 160 TW) on PBFA Z. Shot 51 represents a new record: 1.9 MJ and 200 TW. Incremental improvements to the wire array loads, the vacuum power flow, and the pulse forming lines are responsible for this 25% increase in radiated power. The rise time of the current was decreased by 6 ns (see figure), which increased the current coupled to the load by 2.5%. The azimuthal symmetry of the wire arrays was further enhanced as well.

Improvement in power flow is especially important for smaller diameter arrays, which couple less energy to x rays because of their higher inductance. The reduction in peak current delivered to the wire array and the increased electron loss produce a total radiated energy of 1.1 MJ for a 2-cm-diameter array, compared to 1.9 MJ for a 4-cm array with nearly the same implosion time. Next month we will study the behavior of loads with lower inductance by reducing the gap between the return current can and the outer edge of the wire array. The present gap of 5 mm will be reduced to the 2.5 mm that worked on Saturn. Such a reduction should allow the 3-cm-diameter arrays for the vacuum hohlraum experiments to be as efficient as the 4-cm arrays now are with a 5-mm gap.

Computational and analytic studies reveal two electromagnetic instabilities in an ion diode, and their existence has been confirmed in experiments. Diocotron waves oscillate at a high frequency relative to the time required for an ion beam to pass through the electron sheath and hence do not significantly perturb the ion beam. In contrast, ion mode waves can strongly perturb the ion beam: they oscillate on the order of once in the time for the ions to pass through the electron sheath, causing a dramatic decrease in the beam's ability to focus to a small spot. An inverted pendulum--i.e., a pendulum with its weight at the top--has been constructed to illustrate how diocotron waves of sufficiently large amplitude can prevent the appearance of the ion mode. An infinitesimal perturbation of the inverted pendulum away from vertical normally causes the weight to fall to the bottom. However, if the pivot point of the pendulum oscillates vertically at several times the natural pendulum frequency and at an amplitude greater than ~ 1/5 the pendulum's length, the weight does not fall, provided perturbations that push the pendulum away from vertical are not too large. In a diode, the falling inverted pendulum is the ion mode and the oscillations of the pivot point are the diocotron waves. Large amplitude asymmetries in the ion current density, diode geometry, or electron loss can still overpower the stabilizing effect of the diocotron waves and stimulate the ion mode. We are reducing the amplitude of these perturbations and delaying onset of the ion mode with improved sources and diode modeling tools.

We have now characterized the performance of the NIF prototype power conditioning module for 1000 shots at full charge voltage and completed a 1000 shot test of the baseline gas switch for the system. The switch performed well with no prefires and the erosion rate of the electrodes was as expected. The test module run proved the basic design philosophy, with the output pulse agreeing with the circuit model. The robustness of the design was demonstrated on a shot in which arcing occurred across the high voltage plate and the ground plate; the capacitors and their damping elements were undamaged.

Contact: Jeff Quintenz, Inertial Confinement Fusion Program, Dept. 9502, 505-845-7245, fax: 505-845-7464, email: jpquint@sandia.gov

Highlights are prepared by Mary Ann Sweeney, Dept. 9502, 505-845-7307, fax: 505-845-7890, email: masween@sandia.gov.

Archived copies of the *Highlights* beginning July 1993 are available at http://www.sandia.gov/pulspowr/hedicf/highlights.